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New Trends for Pyrotechnic Automotive Safety in the European Union

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ABSTRACT

In the European Union (EU) pyrotechnic articles are subjected to comply with national regulations in addition to a series of EU Directives. In order to harmonize regulations in the EU, the placing on the market of pyrotechnic articles is going to fall under the scope of a new European Directive. Among these articles, one finds pyrotechnic components of automotive safety equipment such as gas generators or igniters. In the very fast growing market of automotive safety industry, regulations might be perceived as non-technical barriers to innovation in the field. Conversely, through innovation arguments, industries sometimes try to promote specific cases of exemptions to comply various regulations.

In a broad approach, we examine both regulation and industrial recent repercussions in the field of pyrotechnic devices for automotive safety, as these points of view face each other too often. Considerations regarding design, transport classification, approvals, safety features, environmental issues and treatment of end-life waste disposal are provided along the life cycle of the products. We enlighten needs in term of harmonized standards and technical procedures to answer regulation requirements. Such needs bring new perspectives and make room to various stakeholders for possible and efficient developments.

Introduction

More than three decades ago pyrotechnic articles appeared in automotive industry. Pyrotechnics entered first in our car by the steering wheel as energetic component of driver inflatable restraint system commonly known as airbag. This move started in the United States and then reached Europe, mainly through Germany and Sweden where it was proposed as optional equipment for luxury cars at first. But rapidly, airbag flourished in all car manufacturers and was implemented on regular cars as a standard marketing argument for selling new car models. In the mean time, the number of such pyrotechnical equipment multiplied in each vehicle as they showed their efficiency to save lives. After the airbag for the driver came additional passenger, side, and curtain airbags and other automotive pyrotechnic systems such as seat-belt pretensioners (see Figure 1). The tendency turns far away from the time when some people thought unsafe to carry explosive loads on board of a car in motion. Surprisingly, nowadays customers don't pay any attention to

driving their car with hundreds of grams of energetic materials distributed around the passenger compartment.

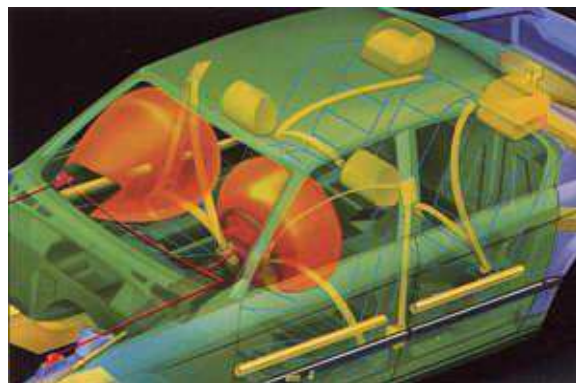


Figure 1: locations of pyrotechnics in a car (steering wheel, dashboard, doors, seat-belts...)

However, in parallel to those developments to safer environment for car passengers, it was known that those articles were potentially dangerous by nature [1]. Several

risks, mainly due to the presence of energetic materials based hazardous components have to be considered: these risks entail unexpected basic explosions and toxic emanations during normal operation of such systems. Moreover, dangers are present on the whole value chain of automotive pyrotechnics devices, comprising equipment manufacturing, transportation to car makers, operations during the car assembly and eventually all along equipment life and even during end life disposal. Safety and security aspects were then with good reason carefully regulated in different countries.

Situation in the EU

In Europe for the moment these pyrotechnic articles (and many others) fall under different national regulations and approval procedures (e.g.: Decree n°90-153 in France [2], Explosives Law in Germany...). Even if, there are similarities between the tests procedures applied in each country, manufacturers of such systems have to pass different approvals to trade their articles in different countries. The test procedures usually consist to submit the items to different stresses (vibrations, drop, impact, heating...). Although the way to apply these solicitations is somewhat different from one country to another, the tests are pertinent enough to detect lack of consistency.

Soon the situation is going to be harmonized to achieve the free movement of pyrotechnic articles in the internal market of the EU and at the same time ensuring a high degree of protection of human health and safety of consumers. Similarly to what have been done for explosives for civil uses (Directive 93/15/EEC of 5 April 1993) a new Directive [3] is about to cover the placing on the market of pyrotechnic articles.

Cases study

Here we discuss cases encountered when testing airbag inflators or other pyrotechnic articles for automotive safety in the frame of the French approval procedure. We believe that other countries have similar experiences and that detailed results have to remain in confidence. We intend to show the need of regulations and test procedures and how they conduct the manufacturer of equipment for motor vehicles to

make safer devices. That has to be achieved not only for "final users" (i.e. car drivers) but more importantly for workers that handle these pyrotechnical items at a low level of integration in inert protective shielding systems.

When exposing airbag gas generator to an external fire some "non-mature" models have shown tendency to break and generate projections at significant distance. That was a clear remainder for those who have forgotten what can happen if an energetic material is placed inside a metallic case under certain conditions. The manufacturers answered those pitfalls by making thicker body case and by crimping and swaging assembly allowing improvement of the mechanical/thermal resistance and relating stress compatibility.

Missile behaviors were also observed as gas ejected through holes may create a significant thrust. In this case it is the whole inflator which is propelled, basically like a rocket, as usually same components produce same effects. Exhausts designed with radial distribution to insure a "neutral thrust" when gases are generated were rapidly adopted as an ideal solution.

When operating, airbag inflators and more generally pyrotechnic devices function primarily as gas generators, through some kind of combustion process. The combustion gases emitted are then converted in several mechanical actions or used directly. Toxicity of the resulting emanations is an issue in passenger compartment, especially due to confinement of a passenger car environment. Early gas generating compositions consisted in mixtures of potassium nitrate, sodium azide and silica, which mainly produce nitrogen gas in a chemical reaction (see Figure 2).

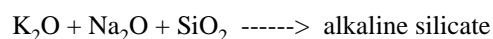
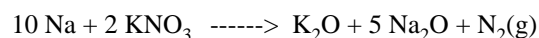
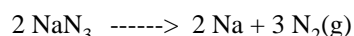


Figure 2: Decomposition of sodium azide

The toxicity of side products generated by decomposition of sodium azide in the reaction process as well as the intrinsic toxicity of sodium azide itself made the technology shift to what is known as "hybrid gas generator". In such a

system, an inert gas is stored under high-pressure in a tank and the pyrotechnic component reduced often to a simple initiator is used to break a rupture disk that releases the gas. But the weight of these inflators due to high-pressure vessel made of stainless steel can present as a significant drawback when large amount of gas is required. Hence, the late trend is to return to the use of propellant at least less toxic as early formulations and with formulations developed to reduce combustion related toxicity as well. Regarding transportation of these pyrotechnic equipment the automotive industry requests to keep constraints at a minimum, in order to cope with the 'zero delay' delivery concept prevailing in the automotive industry. But, by nature of some of their components, these devices have to be viewed as dangerous goods regarding transport regulations. Early consideration of these products concluded to consider them as explosive objects falling in the Class 1 (Explosives) of the United Nations (UN)



Figure 3: UN transport classification for dangerous goods

classification for dangerous goods (see Figure 3). Compromises were found later, under particular conditions, for a classification in Class 9 (Miscellaneous dangerous substances and articles), under UN number 3268 designated as "air bag inflators, or air bag modules, or seat-belt pretensioners". The development of containers with metallic perforated sheets or meshes providing containment of potential projection

without confinement of gases released played an important role for the acceptance of this classification. These containers are essential to allow storage in car manufacturing assembly lines and are also designed to be used as handling devices to avoid unnecessary manipulations in workshop.

Testing procedures

As the automotive equipment technology is moving fast, pyrotechnic items used for safety also evolve quickly and appear now in various systems (e.g.: protection to pedestrians or equipment for motorcycle riders). Moreover, similar items find applications in other field that may not have the same capacity to develop the technology. We can mention as example the "avalanche airbag system" for off-track skier protection, which avoid trapping them under snow. The real need for harmonized test procedures in Europe should soon be covered by the implementation of a new Directive [3], which should indeed cover these articles as well as other pyrotechnics. Similarly, there is a parallel need for test procedures to be able to correctly evaluate new devices.

More and more, considerations to satisfy all test criteria for exclusion of automotive components containing energetic materials from the UN Class 1 are taken into account as soon as the conception phase of the item. Whenever it is possible, this is achieved by containment of all effects inside the object or at least by strong limitation of external effects such as exhaust of hot gas, loud noise, wall heating...

Recycling

Fortunately for the occupants, the majority of pyrotechnic automotive safety systems never operate during the lifetime of the vehicle. Then there is another issue. Process to recycle cars consists to compacting and shredding usually, which can create troubles when applied to energetic materials containing components. In addition to the hazards of explosion that can damage recycling equipment, the dissemination of toxic propellant like sodium azide endangers workers and environment. There are currently no cost-efficient solutions as re-use of second-hand airbags is not easy and not even recommended. Operating all pyrotechnic devices

at the end of their life may not be ideal either [4]. Dismantlement of such devices from the cars requires special care and particular cautions for handling and storing operations before further treatment.

Then regarding environment protection, the issue of treatment of pyrotechnic articles withdrawn from wrecked vehicles is growing, since this aspect was not really considered until recently. There are no reasonable industrial ways for safe disposal and, most often, devices are operated before dismantling.

Conclusion

It is now well established that airbag systems contribute to decrease the number of casualties in car accidents. The technology based on pyrotechnic components has shown its utility in safety automotive systems where a short reaction time is required. But with the multiplication of such equipment in vehicles and of similar items in other fields, pyrotechnic articles are promised to new developments. However, as long as energetic materials will be part of these items, special attention and careful evaluation will have to be taken. In particular consideration of "side safety and environmental issues" on the whole life cycle of such products would gain by putting on the scene more in advance, at the design stage, for more easy and sustainable development.

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